ID-1 Cross-play Study

A Standard Success Story

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(Using the NCITS Flexible Magnetic Media Committee's User Guidelines for ANSI ID-1 Cross-play)

Introduction (A Little History)

ID-1 is an instrumentation digital recording format that was standardized during the late 1980s at about the same time as ID-1 recorders were introduced into the market place. Usually a standard format does not come about this way. Generally standards are generated when the proprietary format of a manufacturer becomes a "de facto standard" which is then adopted by others. Examples of the latter include the VHS format, the 3490 "square tape" formats, and the Phillips audiocassette that we all have in our cars and homes. The ID-1 American National Standard for 19mm cassettes allows for several engineering hardware implementations of recording devices, all capable of making recordings which "meet" the footprint standard. Four companies have manufactured ID-1 recorders since the late 80's and each one uses a different hardware implementation, providing the opportunity for competition in the market and for non-fraternal crossplay among users. While the user groups welcome the competition, the non-fraternal crossplay performance has been less than satisfactory even as late as the mid-90s when the author performed the last investigation of ID-1cross-play[1].

Subsequent to this last investigation, voluntary discussions in the NCITS/B5, Ad Hoc, Instrumentation Tape Group led to the writing of a Technical Report entitled "TR-CCT [Technical Report-Crossplay Calibration Tape] User Guidelines for ANSI ID-1 Cross-play." This document advocates a procedure using a standard reference tape to improve the cross-play between manufacturers. See Appendix A for a description of the procedure. The users, with the help of the manufacturers, took up the challenge to validate the new user guidelines with another round of cross-play testing. This study is the result of that challenge.

General comments of the author on the study results

In almost every case, margin performance of the ID-1 machines in this most recent test, following the committee's TR-CCT User Guidelines, was extremely good when cross-playing recordings made on other machines as evidenced by the low error activity and overall results. This kind of performance indicates consistent electronics set-up and good tracking of the written data as well as very low media defects. This is in stark contrast to the mid-'90s crossplay-test performance that was riddled with high, corrected error rates, erratic tracking performance, and even out-of-conformance footprints. These excellent interchange results are a tribute to the efforts of all of the recording industry players to improve interchange performance since the mid-'90s. Although detail on the improvements is beyond the scope of this paper, the contributing items included improved head to tape contact, improved media noise/output, improved electronic channel performance, and improved mechanical handling of the media. Preliminary results were reported at the B5 committee plenary meeting in September 2000, and the committee immediately agreed that no further testing or study was needed. Their TR-

[1] See "Results of ID-1 Round Robin Testing"; Pub: THIC Forum, October 1996 on website: www.thic.org/

CCT User Guidelines were submitted to the parent NCITS organization for publication as an addendum to the ANSI ID-1 standard.

In addition to performing the procedures as per the TR-CCT User Guidelines for ANSI ID-1 Cross-play, there were two testing labs involved that were 140 miles apart. Results presented here also reflect the effect of uncontrolled TH cycles and vibration encountered in Federal Express shipments of the recordings between these two labs.
This was a voluntary effort on the part of the participants and many thanks are due to the people who helped at Quantegy, Sony, SAIC, Enertec, Metrum-Datatape, SyntheSys Research, and Bow Industries.

Criteria and procedures used in the CCT crossplay testing

Several Bitalyzer 400s and Bitalyzer 622s were used to generate and analyze the cross-play data. The criteria for judging a successful crossplay was the same as that used in the mid-‘90s testing; a corrected error rate of 1E-10 or better, excluding up to one error burst. The first and last 3% of the tape were ignored on medium cassettes and the first and last 1.5-% of the tape was ignored on large cassettes. All testing was performed over the entire surface of the tape in a medium D-1 cassette or a large D-1 cassette except for a few recordings on large cassettes that only recorded half the surface; equivalent to a medium cassette. Also, a few recordings were made with half the tape at full rate and the other half at half rate.

All media was bulk degaussed and cleaned prior to recording except for one or two of the Enertec recordings. The winder/cleaners used were BOW, 19mm cassette versions using double tissue wipes on both tape sides and a single sapphire blade on the oxide. Four cleaning passes, two in each direction, were performed on all tapes prior to making the recordings. After cleaning, degaussing, and first recording, only media that had either no error bursts or one hard error burst were used in subsequent testing. This pre-screening had the effect of eliminating about 40% of the tapes that were donated for the testing. All testing was performed by either Government personnel or SAIC under Government contract and all personnel were very familiar with ID-1 recorders. All interchanges were performed at the highest rate of the drive unless noted in the data. The tape drives used in this testing were typically not cleaned on each pass but rather were closely monitored by the operators and cleaned when necessary. Cleaning typically consisted of an alcohol wipe of the heads. If that did not improve performance then a cleaning tape was inserted and run. If that did not improve performance a vendor representative was called for corrective action.

The typical crossplay attempt progressed as follows:
-an attempt was made to auto track at the beginning of data; if that failed or if attempts gave erratic tracking values then
-an attempt was made to auto track several thousand track-sets past the beginning of data; if that failed then
-an attempt was made to find the best manual tracking position using inner error correction activity several thousand TSIDs from the beginning of data.

Summary Data Table 1: 25 recordings, 72 interchanges

Recording ID number	LP400 S/N 1025		DIR 1000 S/N various		DIR 1000H S/N 10078		Enertec DV 6421 S/N 133R	
	outcome	tracking	outcome	tracking	outcome	tracking	outcome	tracking
3QSH08229999	G 3		G 4	V7B	write		G5	-5,-20
2QSH03010099	G 2*,3*	-02*	G 4,5	V7D	write		not	tested
1QSH03010099	G 4*,5*	-0D*	G 3	V81	write		G 2	+5
1QSH03090000	G 4	-03	G 3	V7D	write		G 5	+25
1SSH083000	P 8	-0B	G 5,6	V80	write		G 9	+50
1SSH07309998	X 10; G 12,13	various-1C,-1A	X 6 P17	V7F V7C	write G 11	V00	g 14	+35,+45
1QS108029999	G 2,3	-1D	write		G 4		G 5,6	N/A
1QS103220000	G 2,3	-1D	write		G 4	V-0A	G 5	-45
1SS102250098	g 6*	-13*	write		G 3,4	V-03	g 8,9	-25
1SS1080700	g 8	-23	write		G 3	V00	X 12	+5
1QLP081100	write*		M 6^	V87	M 4	V00	G 7	+5
1QLP03010099	write		M 5	V8C	G 2	V+0B	G 6	+5
2QLP03019998	write		G 3	V84	G 4	V+0A	G 2	-25
1SLP03230098	write		G 2,3	V81	G 4	V-02	G 5	-10
1SLP03020098	write		M 9	V7C	G z, 7	V00	g 5	+5
1QEN080400	G 4	-1E	G 3	V82	G 2	V+02	write	
1SEN080800	G 6	-29	G 7	V81	G 4	V+03	write	
1QEN051800	M 6	-12	G 4,5	V88	G 7	V+01	write	
1SEN051500	P 12	-17	P 7	V86	G 9	V+01	write	
2QEN080400	G 3*	-15*	G 4	V82	G 2	V+02	write	
1QEN080700	G 4*	-10*	G 5	V83	G 3	V+02	write	
2SEN080800	g 4,5	-0F	G 7	V83	G 6	V+03	write	
1ASH042400	G 4*,5*	-01*	G 2,3	V83	write	Ampex	X (see	report)
1AS1032900	M 2*	-09*	write	Ampex	g 4,5	V-08	not	tested
1ALP032900	write	Ampex	G z,z	V83	M z	V-07	not	tested

Failure rate: 3 out of 65 crossplay attempts or 4.6% (Ampex tapes excluded)
Failure rate for Ampex media: zero out of six attempts or 0%
In the outcome column, the numbers following the letters in the data represent the pass number, with the record pass numbered 1, for that recording. In some cases the operator did not jot down the pass number so a lower case z represents this.

g = 10E-10 in auto track but tracking algorithm did not pick consistently good settings that would pass criteria
G = 10E-10 in auto track, consistent automatic tracking settings
X = failed to pass criteria for crossplay in either auto or manual tracking
M = 10E-10 in manual track because automatic tracking would not pick a satisfactory setting
P = 10E-10 Failed to pass criteria on several tries but passed in automatic tracking after a cleaning
* written or read during a period when there was an intermittent gimbaled roller on the LP400 - may have affected interchange performance and/or tracking position.

^ interchanged during a period when the tape path in the DIR1000 was suspected to be out of specification.

For each attempted cross-play head-wear, temperature, and humidity were recorded and are available from the author.

For the next three tables, the letters represent the degree of success as per the notes in the previous table and the numbers represent the quantity of recordings that completed the cross-play between the two recorders.

Table 2 Interchange - Ampex video grade 229 media

Write drive column	LP400	DIR 1000	DIR 1000H
LP 400		G	M
DIR 1000	M*		g
DIR 1000H	G	G	

The previous interchange table entitled, Interchange - Ampex video grade 229 media, was an attempt to discover how rehabilitated Ampex 229, video grade media would fare under the new cross-play calibration procedure. These tapes were not included in the computation of the rate of success since Ampex no longer manufactures D-1 media. There is no data for these tapes on the Enertec DV6421 because the Ampex cassette shells failed to physically fit into the cassette opening in the Enertec machine.

Since the record equalization of the LP400 was aligned to SD1-A (~1000 Oe), the Ampex 229 media (~750 Oe) was most likely being magnetically saturated. This would result in less than optimum frequency response on recordings made by the LP400.

Three rehabilitated Ampex tapes were tested as a sort of control to see how the present day drives, set up to the TR-CCT User Guidelines, were able to handle the video grade media that was used in the cross-play testing conducted by the author in the mid-90s. They were also tested because there is still a large quantity of this media in Government use. These tapes were subjected to the same cleaning and degaussing as the higher coercivity Sony and Quantegy media.

These tapes did exhibit a higher percentage of tracking anomalies than the SD-1A and D1V media. Background error rate, as judged by individual channel error activity, was negligible. This indicates that the improvements in the hardware, combined with the consistent playback equalizer settings obtained by following the B5 crossplay TR-CCT User Guidelines, has resulted in improved interchange compared to the mid-‘90s testing when background error rates were all over the map and 22% of interchange attempts failed.

Table 3 Interchange - Quantegy D1V Media

Write drive column	LP400	DIR 1000	DIR 1000H	DV 6421
LP 400		2M, 1G	1M, 2G	3G
DIR 1000	2G		2G	2G
DIR 1000H	4G	4G		3G
DV 6421	4G	4G	4G	

Table 4 Interchange - Sony SD1-A Media

Write drive column	LP400	DIR 1000	DIR 1000H	DV 6421
LP 400		1G, 1M	2G	1G, 1g
DIR 1000	2g		2G	1g, 1X
DIR 1000H	1P, 1X	1G, 1X		1G, 1g
DV 6421	1G, 1g,1P	2G, 1P	3G	

Tables 3 and 4 segregate the results according to media and recorder manufacturer. The Sony DIR1000H never failed to successfully play an interchange recording and the Metrum-Datatape LP400 never produced a recording that failed to interchange with all the other machines. Of note is the fact that no interchange failures were seen using Quantegy media. In fact two of the three manually tracked interchanges using Quantegy media were with a tape written during a period when there was an intermittent gimbaled roller on the LP400 that may have affected interchange and/or tracking performance.

Philosophy behind the TR-CCT User Guidelines

The primary idea is to improve non-fraternal interchange performance through the use of a standard reference tape. In addition the committee members agreed to adopt the Sony Corporation suggestion that "cold" reference media should be used.

By using a pre-recorded standard reference tape, all ID-1 recorders would be set up to the same standard, independent of manufacture. This then guarantees that all recorders will reproduce recordings the same way as their non-fraternal brothers. In addition to the pre-recorded reference tape, known as the cross-play calibration tape or CCT, standard unrecorded secondary reference media is used to set up the record side of all the ID-1 recorders. This ensures that all the machines will generate recordings that have the same record equalization and in theory these recordings should play well on non-fraternal machines.

In manufacturing the standard unrecorded reference media, Sony has suggested that they use "cold" media. This means that the response of the media at the highest frequencies is about 2-3 dB lower than typical data grade media. This has the effect of producing a high frequency boost in the record/reproduce channels compared to the equalization setting one would get using typical media. The "cold" media also has lower signal-to-noise ratio and this helps by producing a more restricted range of equalizer settings compared to typical media. This was viewed as a good thing because ID-1 technicians had always complained about where to set the equalization when there was such a wide range of acceptable equalization settings using typical media.

Notes on the set-up and performance of the drives

Except for the Sony DIR1000H, all the recorders were dedicated exclusively to the cross-play testing. The 1000H was an operational machine that was being used constantly with Ampex video grade media and some Sony SD1A media. For cross-play testing it was temporarily pulled from operational use as needed. In the worst case this meant that we were using a machine where the head contour was conditioned by the high abrasivity of the Ampex video media. The effect on the cross-play testing is unknown.

All testing was performed at the highest tape speed of the drive under test unless noted otherwise in the data. The rates of the drives in megabits per second:

Sony DIR1000 -- 256
Sony DIR 1000H -- 512
Enertec DV6421 – 260
Metrum-Datatape LP400 – 400

There are no adjustments on the Sony recorders so they were used as is. The LP400 play side was aligned to the Cross-play Calibration Tape by a Metrum-Datatape technician and all channels were deemed good. The record side was initially set-up with Sony SD1A media and that resulted in all record play head pairs exhibiting extremely low error activity except for channel 7 which exhibited a continuous low value of error activity. The LP400 has a memory bank for setting the record parameters for more than one media, so the technician set up the second set of values using Quantegy D1V media. These D1V values were so close to the SD1A values that he decided not to bother with using the second set of record values for the testing. Therefore all the LP400 recordings were made using the same set of record side values. To the author this says that the magnetic and surface characteristics of the SD1A and the D1V media are identical for all practical purposes.

The DV 6421 reproduce side was aligned to the CCT by an Enertec technician and all channels were deemed good. The record side was set up using Sony SD1A media but was found to perform slightly better (operator opinion) using Quantegy D1V media. No cleaning of either heads or tape path was performed between cross-play attempts unless uncorrected error rate performance indicated that it was necessary.

Conclusions

True multi-vendor crossplay has been achieved with this format using the crossplay calibration tape and the User Guidelines written by the B5 committee of the National Committees for Information Technology and Systems. The failure rate in the mid-‘90s using different media and no reference tape was 22%. The current round of tests, although not concluded, have a 4.6% failure rate indicating a phenomenal improvement and what must be categorized by all as successful interchange.

Error activity on almost every recording that crossplayed in this testing was extremely low. The superficial reason for the failures and the need for manual tracking intervention were the appearance of a few burst errors and also some obvious anomalies with autotracking algorithms. The underlying reason for these burst errors is the issue. Are they due to self-generated debris? Are they due to dirt generated by the drive? Are they due to unexplained mistracking events? Are they due to the fact that the automatic tracking is performed at the very beginning of the tape – a less than ideal location? All of these are beyond the scope of this testing.

In spite of these anomalies, it is safe to say that enterprises using the new procedure can expect interchange performance to equal the performance experienced at the time of the original recording. Moreover, if the user is interested in error free interchange, the data here shows that one can attain that performance if he is willing to pre-certify the media and allow for operators to occasionally adjust the tracking of the playback drive when automatic tracking algorithms fail to pick the best tracking position.

Recommendations

1. Because very good cross-play was achieved by using the Sony Cross-play Calibration Tape in conjunction with the NCITS/TR-CCT User Guidelines (alignment procedure), it is recommended that all users of the ID-1 equipment begin to use the Sony Cross-

play Calibration Tape and the TR-CCT User Guidelines.

2. This set of data indicates that improved plug-and-play performance could be obtained if the automatic tracking algorithms on all the drives had been more consistent. Individual machine vendors should investigate the value of researching and redesigning the automatic tracking algorithms with an eye towards non-fraternal crossplay. This would probably require inter-vendor cooperation. The most expedient solution would be to have the vendors meet on their own to discuss this possibility.

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Appendix A: Outline of the TR-CCT User Guidelines, for a single tape speed

A. Ensure that the ID-1 drive under test is performing to the manufacturers specification and ensure that the heads and tape path are clean. Insert a Cross-play Calibration Reference Tape (CCT is manufactured by Sony) into the drive and align the playback electronics minimizing the error rate on each head channel.
B. Remove the Cross-play Calibration Reference Tape from the drive under test and insert a standard, data grade, unrecorded, secondary reference media. (If no secondary reference media is available, use unrecorded media of the type most likely to be encountered under operating conditions.) Align the record electronics to minimize the error rate on each head channel.

Appendix B: Commentary on the problem interchanges

Recording ID number	LP400 S/N 1025		DIR 1000 S/N various		DIR 1000H S/N 10078		Enertec DV 6421 S/N 133R	
	outcome	tracking			outcome	tracking	outcome	tracking
1SS1080700	g 8	-23	write	N/A	G 3	V00	X 12	+5

1SS1080700 --- Playback on the DIR1000H was uneventful. Passes 4, 5, and 6 on the LP400 were full of errors. A drive problem was suspected and found to be a bad, gimbaled roller on the input side of the scanner so passes 4-6 were discounted. It appeared that the roller had ceased to gimbal properly, although it was rolling OK. On pass 7, even though there was virtually no error corrector activity, 2 bursts appeared; automatic tracking picked a value of -1B. On pass 8 the LP400 tracking algorithm picked –23 and played without any burst errors. The recording was then sent by Federal Express to SAIC for testing on the Enertec drive. The remaining passes were all on the DV 6421 and exhibited low error rate. All failed due to small numbers of bursts on each pass.

Recording ID number	LP400 S/N 1025 outcome	DIR 1000 S/N various outcome	DIR 1000H S/N 10078 outcome	Enertec DV 6421 S/N 133R
1SEN051500	P 12	P 7	G 9	Record pass

1SEN051500 ---Originally recorded on the Enertec DV6421, SD1A media. The initial attempted cross-plays were with the DIR1000 (S/N50902). Attempts 2 through 6 were problematic and produced a small number of burst errors in both automatic and manual tracking modes. (Remember that V80 is the center of the tracking range on the

DIR1000.) The DIR1000 picked high tracking values, above V85. The operator chose to put the recording through a four pass cleaning cycle on the Bow Winder/Cleaner and pass 7 on the DIR1000 produced no errors but was still riding high at an autotrack value of V86. On to the DIR1000H where two attempts were made. Pass 8 was probably error free but "operator" error with the bit error rate test set prevented verification. The 1000H autotracked at V7F (pass 8) and V7D (pass 9) and produced no errors on pass nine. On to the LP400 where three attempts were made. Pass 10 had two bursts and pass 11 had four bursts, but the LP400 autotracked both passes at –19. Error activity was low on these two passes, so the operator chose to put the recording through a 4 pass cleaning cycle on the BOW winder cleaner and pass 12 was error free at a –17 auto track value.

Recording ID number	LP400 S/N 1025	DIR 1000 S/N various outcome	DIR 1000H S/N 10078 outcome	Enertec DV 6421 S/N 133R outcome
1QLP081100	Record pass*	M 6^	M 4	G 7

1QLP081100---- Originally recorded on the LP400 using D1V media. At the time of the recording, the LP400 had exhibited what later proved to be an intermittent gimbaled roller. The effect that this mechanical problem had on the recording is not known. Pass two was run on the DIR1000 S/N50906 which autotracked at V86 but "operator" trouble with the Bitalyzer prevented a valid burst error count. The error free intervals were extremely quiet. On to the DIR1000H. Pass 3 autotracked at V+0B but had in excess of 7 bursts; error activity was high. Several other attempts to let the 1000H automatically select a good tracking position failed and were aborted. Pass four was a manual tracking position at V00 and was error free with medium error activity. On 8-28-00 this recording was tried on the other DIR1000, S/N50902, where two attempts were made. Pass five auto-tracked at V80 with in excess of 13 bursts; error activity was high. Pass six manual tracked at V87, ran error free and had virtually no error activity. Three days later this drive was deemed in need of maintenance and so pass five and six may not be indicative of a typical drive. The tape was then sent to SAIC via Federal Express and played error free with low error corrector activity on the DV6421.

Recording ID number	LP400 S/N 1025		DIR 1000 S/N various		DIR 1000H S/N 10078		Enertec DV 6421 S/N 133R	
1SSH07309998	X 10; G 12,13	various- 1C,-1A	X 6 P17	V7F V7C	write G 11	N/A V00	g 14	+35,+45

1SSH07309998--- It is interesting to note that 13 months elapsed between the recording date and the crossplay attempts. During that time the tape was moved from one cabinet to another in a different room but was not run on a machine or taken out of its container. Originally recorded on the DIR1000H using SD1A media. First record pass recorded a section at 512Mbps and an additional recorded section at 256Mbps. Pass three was a play pass on the DIR1000H and was error free. On to the DIR1000 S/N50906 where three passes were attempted. All three passes had low error activity. Pass 4 and 5 autotracked at V7C and had 2 and 3 burst errors respectively. Pass 6 was manually tracked at V7F and had four error bursts. On to the LP400, which picked inconsistent auto track values. Therefore, passes 7-10 were all manually tracked at

various values and all of these produced more than 2 bursts per pass. Error activity was very low. On to the DIR1000H for a control pass. The result was an error free pass 11 at auto track value V00. Back to the LP400. Note that the LP400 autotracking algorithm re-engages if data is lost so on this recording, it picked two different values, one for each of the recorded rates. Pass 12 was error free at autotrack values –26 & -1C. Pass 13 had one burst error and autotracked at –26 & -1A. Since the DIR1000H has sapphire blades that scrape the oxide, it could be that pass 11 acted as a cleaning pass. This would explain why the bursts disappeared on pass 12 if the bursts were due to debris. On to the DV6421. This machine would not pick a consistent tracking value at the beginning of the tape so the operator chose to let it auto-track about 25 feet in from the beginning where it was more consistent. It played the 512Mbps section error free at auto-track value +35 on pass 14. The 256Mbps section also played error free at auto-track value +45. The recording was then carried in a privately owned vehicle to the Fort Meade lab. As an afterthought, the author replayed this recording in the DIR 1000 and on pass 15 it produced 3 bursts at V7B. On pass 16 it produced 2 bursts at V7D. Error activity was very low, however, so it was subjected to a four pass cleaning cycle on the BOW winder cleaner. After that it automatically tracked at V7C and played error free on pass 17 indicating that debris had been removed.

Recording ID number	LP400 S/N 1025 outcome	DIR 1000 S/N various outcome	DIR 1000H S/N 10078	Enertec DV 6421 S/N 133R outcome
1SSH083000	P 8	G 5,6	Record pass	G 9

1SSH083000---Originally recorded on the DIR1000H using SD1A media. The crossplay attempts were made one day after the recording was generated. Pass two and three were attempted on the DIR1000 S/N50902 and autotracked at V86 & V85 respectively. Low error activity seen but burst errors were in the double digits. A manually tracked pass 4 produced similar results at a value of V89. Operator personnel suspected something wrong with the tape path of the DIR1000 deck so the recording was tried in another DIR1000, S/N 50906. Pass 5 and 6 autotracked at V80 and V80 respectively and had one burst each and very low error activity. On to the LP400 where several attempts were aborted due to a few, mobile error bursts. At this point the operator should have tried to manually track the LP400 but instead, he chose to clean the tape. The final error free pass on the LP400 was obtained in automatic tracking mode after a four pass cleaning cycle on the Bow winder/cleaner. Cleaning of the LP400 tape path produced no visible debris on the cleaning cloths. The tape was then shipped via Federal Express to SAIC and played error free on the DV6421.